Poultry Growers' Control Strategies and their Evolution

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This paper presents a model for understanding the evolution of worker strategies in rural northern Mozambique, an industrially developing agricultural region. We reviewed administrative data on grower productivity from an integrated poultry operation, visited three grower chicken houses, and followed-up with informal discussions with the integrator, examining tasks and strategies related to productivity. Defining strategy as a mode of behavior that demands a resource profile and generates a performance profile that depends on the environment, we discuss examples of strategies and their adaptation over three time horizons. These time horizons are exemplified in the poultry growing domain as the critical brooding period following birth, the weekly routine within a growing cycle, and the span of months comprised of several growing cycles. Responding to observed flock characteristics, growers used behavioral indicators of health to adjust temperature; used heuristics to adjust feed based on measured weight; and constructed items to reduce exposure of the flock to disease. Growers adapted strategies according to the work context. Heat control strategies, for example, varied seasonally. Viewing strategy change in the context of a self-regulation model in which growers actively control their work environment reveals interactions over time horizons, which range from minutes to months, and link micro and macro-cognition. The self-regulation model also suggests that strategy change creates experiences that enrich the grower's conceptual models and improve skills, which in turn enable new strategies. Investigating growers' control strategies can reveal interactions between micro and macro-cognition that influence strategy development and change.

INTRODUCTION

Human malnutrition is a serious problem in many parts of the world, particularly where there is very little industrial development. A successful domestic livestock industry can improve the nutritional status of a population, while at the same time promoting economic growth by providing work for growers and processors. However, poorly resourced regions are challenged by limited water, feed and infrastructure, all of which make livestock – in this case poultry – vulnerable to disease and predation. In Ethiopia for example, consistent violations of bio-security standards led to the outbreaks of multiple diseases for three large poultry growers (each housing 6000 to 10000 chickens) in 2008, and the subsequent failure of these businesses (Chanie, Negash, & Tilahun, 2009).

Globally accepted bio-security standards for a broiler chicken house include procedures for sanitation, disinfection, bedding management, disease monitoring, disease response, and vaccination (OIE, 2008). Standards exist to control access and exposure to humans, outside birds and other animals, particularly rodents and pests. In addition, within the commercial industry there are established standards for nutrition and housing. Poultry quality and productivity are directly linked to adherence to standards through measures of productivity, such as weight gain per unit of feed (Garcês, 2008).

We study the 'broiler chicken house' subsystem of an integrated broiler production system in a rural area of a high agricultural potential in northern Mozambique – a region with an annual per capita income of less than $150. Ergonomic research in such industrially developing settings has identified many occupational health and safety issues in addition to cross cultural issues relating to the transfer of knowledge and technology (Kawakami & Kogi, 2005; O'Neill, 2000). As workers become more involved in the management and ownership of their enterprises they gain control over their work environment, but the work requires they perform new tasks in adapting new tools and adapting to new tools.

Growers' primary tasks involve providing care to chickens, including food, water, vaccinations, and an environment conducive to healthy growth. The provision of care depends on control tasks that require knowledge specific to broiler poultry care. Some examples are the control of poultry feeding, temperature regulation, and managing poultry activity. From a work system perspective, commercial poultry growing – a developing industry in sub-Saharan Africa – involves many control tasks that are novel to the workers of this region. Growers approach these tasks with a range of strategies, each of which has different resource requirements and performance outcomes.

We define strategy as a mode of behavior that demands a resource profile and generates a performance profile that depends on the environment. Although worker strategies have been studied in many industries, most notably aviation, electronics troubleshooting, nuclear plant operation, and health care, they have not been studied in industrially developing settings from a cognitive perspective (Amalberti & Deblon, 1992; Gaba, 1994; Rasmussen, 1981; Vicente, Mumaw & Roth, 2004). Developing and adapting effective control strategies is important to successful, sustainable enterprise in industrially developing work settings. This paper presents a model for understanding evolution of worker strategies in an industrially developing setting.

One approach defines strategies in terms of information processing functions and consequent actions and their outcomes that fit a given situation – i.e., a set of constraints defined by the task goal, the environment, and the worker's individual resources – shown in Figure 1 (Rasmussen, Pejtersen, & Goodstein, 1994). From their studies of strategies in various work domains, Rasmussen and colleagues constructed a classification of diagnosis, search, and troubleshooting strategies based on workers' processing of work system data, i.e. information on the situation, including the environment and resources, their mental model of the work domain, i.e., their understanding of the constraints, their tactics, or sequencing of information processing in decision making, and their actions, consequences or changes in situation. Studying troubleshooting, they found that engineers drew more upon their knowledge resources and less on observation of work, whereas technicians used frequent observation, seldom drawing on mental models. They also found that strategies have different resource requirements and workers switched strategies in response to work demands. Their findings also suggest that the actions along with changes in the situation and worker mental model feed into new tactics and associated strategies.

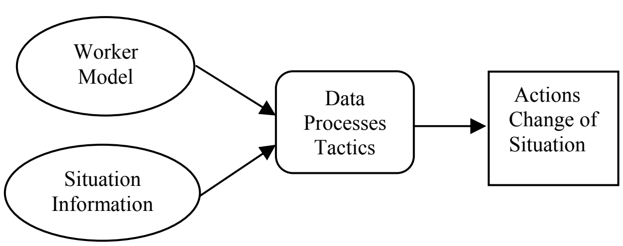

Figure 1. A model of strategy that links knowledge and the situation to actions (based on Rasmussen 1981, 1986).

Following Rasmussen, we identify strategies, the resource profile they require, performance outcomes they support, and conditions under which growers switch strategies, focusing further on the changes in situation in relation to increased work demands, and with a view toward identifying how to support effective strategy adaptation.

METHODS

We reviewed administrative data on grower productivity from an integrated poultry operation, visited three grower chicken houses – each at different stages in the growing cycle – and followed-up with informal discussions with the integrator. These visits occurred between June and July 2009. Analyzing these data through the lens outlined in Figure 1, the results identify the constraints that shape grower behavior, the information created by the work process and used by the grower, the strategies adopted, and the consequences of those strategies to identify how strategies evolve in this setting. The resulting framework describes strategy development and change in the context of radical work changes, a situation typical of developing countries, but also the situation of established operations facing radical change.

RESULTS

Work System and Organization

Poultry production involves several phases occurring in different settings from egg production, hatching, brooding and rearing, to slaughter, processing, and marketing. An integrated organization distributes poultry growing among independently operated broiler houses, each of these caring for several hundred to as many as two thousand chicks from the first to the thirty-fourth day of life. In the system under study, the grower contracts with the integrator for day old chicks, their feed and technical support – including training, technical consultation , vaccines, medicines, and feed. The integrator also makes available credit for investment into housing for chickens and equipment. In return, growers must meet production requirements and keep accurate records, or they will be expelled from the program. After thirty-five days, the integrator buys back chickens, paying the grower on the basis of their weight.

The chicken house is family operated – or in rare cases a multifamily operation – involving one to three adults. For most of these poultry growers, this is their first formally contracted work experience. Although this integrated structure alone does not necessarily bring about strategy adaptation, it radically alters growers' task environment in the chicken house. The integrated broiler production system is a radical change in a rural industrially underdeveloped setting because growers have access to previously unavailable resources, must act within new constraints, and so must engage many new strategies to succeed.

Task and Strategy over Three Time Horizons

Our visits to the growers' chicken houses, discussions with integrators and technical advisors, and analysis of the task artifacts, revealed three time horizons as a natural basis for describing the tasks and strategies relevant to the grower work system. These time horizons are characterized by operational activities during the critical brooding period taking place over minutes to hours; tactical activities over several days to weeks, often in response to the weekly advisor visits; and strategic activities taking place over several growing cycles or several months. For each of these time horizons, we describe the environmental constraints and resources, system state data available to the grower, as well as strategies and their consequences.

1. *Brooding period (Minutes).* The brooding period extends for two weeks from the arrival of day old chicks. During this period of intensive care the objective is to assure chick survival.

Constraints and Resources: Best practices demand that during this time the house must be kept at a temperature starting at 32C and over two weeks decreasing to 29C using charcoal stoves. Water and feed should be freely available and strategically located to maximize activity and to make best use of available heat. Nighttime illumination is by electric bulbs where there is electrical power, but often by candlelight. Stoves and candles must be monitored as they present fire hazards. Electrical lights must be monitored in case of power failures and burnouts. 'Best practice' calls for twice-daily checks and standardized temperatures.

Data: Because of significant temperature gradients in the chicken house, the best indicators of sufficient heat are the spatial distribution and sound level of the chicks. Also, their kind and level of activity indicate whether they are feeding and drinking properly.

Strategy: The grower observes levels of water, feed, heat and flock patterns, diagnoses the state, determines the adjustment needed, and makes the adjustment, exhibiting feedback control. Variations in this strategy depend on the perceived criticality and resource availability. Some growers chose a strategy in which they remain in the chicken house, minimizing hand offs, while monitoring resources (heat and light and water) to maintain the flock in a steady state. Some growers hand off, but only to family members during brooding because the brooding period is so critical. Others perceive the conditions to be sufficiently stable to follow prescribed periodic adjustments with occasional observation, exhibiting open-loop control.

Consequences: The direct outcome of these strategies is the survival of chicks past this critical period. Poor survival rates lead to business failure or to steps taken to address resource shortages material and human that lead to failure. The outcomes of these operational strategies therefore sometimes depend on prior activity over a longer time horizon, to be discussed below. Insufficient supply of water and charcoal are major grower-reported reasons for failures to meet or exceed targets.

2. *Weight gain and stock supply (Weeks).* The brooding period ends after a couple weeks with the chicks having developed sufficient metabolic control so that heat and light supply become less critical.

Constraints and resources: Over the following two and half weeks, the main objective is to control weight gain. Aside from routine tasks, the grower attends to resource supply tasks at a longer time horizon than the time-critical adjustments of the brooding period when the chicks are fragile. Controlling feed is a routine task for which growers use various strategies.

Data: Growers use a growth chart as a control mechanism for adjusting feed. It supports strategies by showing the gap between actual weight and target weight and therefore improves adaptive control. The desired weight gain is the existing gap plus the difference between the two weekly targets. The desired weight gain determines the amount of feed required. Without growth charts, growers might not provide sufficient feed to the chicks.

Strategies: The weekly growth charts we reviewed suggest that some growers adopt satisficing strategies that deviate from prescribed feed use, to meet the growth requirements by the end of growing cycle. The charts also suggest that these growers' strategies involve heuristics for estimating the feed requirements. Instead of following the advisor's recommended adjustment, some growers adjust the amount of feed by estimating how much they need to feed so that they meet minimum requirements to stay in the program. The estimated amount of feed is then removed from the feed supply for private use. Other strategies at this time horizon include stockpiling charcoal and water. Stocking sufficient resources in reserve is a strategy for responding to unanticipated resource demands.

Consequences: Weight gains are typically below targets, resulting in an artificially high feed-conversion ratio. The integrator compares feed conversion ratios with a standardized flock to control for feed quality.

When feed is diverted for personal use, the estimate of feed conversion ratio is biased, masking other nutritional effects. Stockpiling charcoal and clean water affect the utilization of these resources during the critical periods when there is not sufficient time to replenish spent resources. Stockpiling also incurs storage costs and a risk of theft. Growers often lack funds for investment at the time the investment is needed, so that stockpiling of charcoal or water, if carried out, may not be effectively safeguarded.

3. Growing cycle (Months). Growers responded over several cycles to mitigate health hazards by constructing and using external bamboo fences with gates and locks to decrease exposure to predators and disease vectors.

Constraints and resources: Unvaccinated free running birds that do not belong to the flock are a major disease threat to the housed flock. This strategy involved buying materials, gathering necessary construction tools, and building and installing fences to protect the flock. These activities required time and additional assets. The integrator assisted with financing.

Data: Several outbreaks of disease occurred, suggesting that flocks were exposed to free range birds and possibly other vectors.

Strategies: The accepted practice for protecting the flock against intruding predators and vectors was to locate the entrance on the side facing away from public areas or traffic corridors. This strategy failed. Following outbreaks among different chicken houses, one grower constructed a bamboo fence around their chicken house to further restrict access to the chicken house. The success of this strategy caused other growers to adopt this approach.

Consequences: Growers who constructed fences around their chicken houses experienced reduced flock mortality and higher profits. The increased protection also freed time growers previously spent guarding the entry.

DISCUSSION

The model shown in Figure 1 describes strategy change at a single time horizon and only as a consequence of changes in situation and worker model. The model does not consider parallel activities taking place at multiple time horizons and therefore interactions across multiple time horizons, particularly those that interact with the strategic time horizon, such as in the construction of equipment. We noted examples of strategies occurring at three different time horizons, reflecting the phases in the work cycle. Growers' strategies at one time horizon had consequences for other time horizons. Figure 2 shows a revised model for strategy change that includes these levels and explains their role in strategy change. The revised model shown in Figure 2 is adapted from a model of interactions across time horizons describing driver distraction (Lee, 2010).

While strategies within each of these time horizons were found to vary as postulated in Figure 1, each time horizon redefines the situation so that strategies across time horizons differ in terms of how knowledge and situation data are used and the consequences of the strategies. In addition, the consequences of strategies at one time horizon require strategy changes at other time horizons. Growers switched strategies in response to resource demands, and this led to changes in strategies at other levels.

Operational adjustment strategies. At the operational level, use of situation data and knowledge varied with skill level of grower. More experienced growers knew from chicken behavior the state of the system and therefore spent more time in the chicken house. Less experienced growers followed recommended schedules.

Interruptions in supply – such as running out of charcoal when it is unseasonably cold, or water during the dry season – presented resource demand conflicts that required action at the tactical level. Without a stockpile, charcoal is rationed and the birds suffer.

Tactical supply strategies. Tactical supply strategies required the use of artifacts for combining past data with mental models to estimate future requirements.

Changes in the supply tactics for charcoal, feed, or water occur at the tactical level and affect utilization of feed at the operational level. Such changes in the supply strategy at the tactical time horizon often follow as a result of experience and advisor recommendation. Thus resource availability at the tactical level interacts with the operational level by affecting resource utilization.

Changes in strategy at the tactical level had varying consequences. Stockpiling charcoal in the off-season improved heat control; however, the tactics of handing off and growth chart use produced mixed results, much of which may be limited more by grower mental model than by experience.

Adaptive control strategies. Strategic changes, such as electrifying heating and illumination, are difficult for the grower to initiate independently because these interventions involve external resources. Some actions, such as building a fence, required external financing, materials, and equipment. Constructing fences called for new activities (building fences) to fit a new goal (reduce disease vulnerability by keeping free-running birds at a distance) and eliminated other activities (chase away free-running birds when they are near the entry to the chicken house). Other possible adaptive control strategies with cascade effects include building storage facilities for charcoal and water in response to the risks discussed above associated with stockpiling. Such strategies would facilitate existing and new strategies at the shorter time horizons. Thus at the strategic level, strategies involving tool development and manipulating the environment sometimes imply radical change for strategies at lower levels.

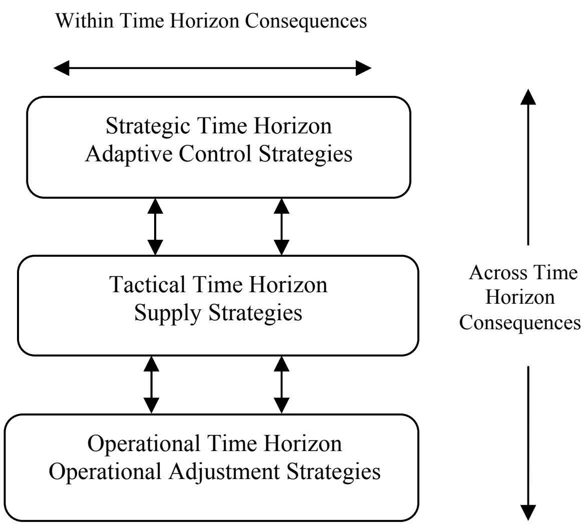

Figure 2. A framework for strategy evolution as a consequence of interactions across time horizons.

In Figure 2, strategies at different time horizons are linked through cascade effects (vertical arrows), where changes at one level initiate disruptions and create opportunities for action at other levels (Lee, 2010).

This model provides avenues for investigating unanticipated consequences, either synergistic or disintegrative ones. Usually these levels of control are presented in separate knowledge domains using different units of analysis. Strategy change at the strategic time horizon involves macro-cognitive functions, whereas strategy change at the operational level involves micro-cognition. Rather than being considered as separate processes, this model of strategy adaptation stresses the coupling between levels: micro-cognition influences macro-cognition and vice versa (Lee, 2010). Time scale at each horizon is a key factor in this model, having important implications for strategy evolution. These examples, in terms of the revised model of Figure 2, suggest that strategy development is an essential part of work system development.

CONCLUSION

The current study shows how interactions over different time horizons influence strategy evolution in an industrially developing setting. This research forms the exploratory phase to be followed by an in depth study of strategies using the revised model. Viewing workers in adverse settings as controllers of resources, with a framework that explicitly shows interactions created by strategies over different time horizons enables industrial development specialists to design and test organizational arrangements, tools, and information technologies that promote self regulation. More generally, this analysis considers workers' strategies in responding to radical change in a work system.

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